

Analysis of the Operational Risk Sources in Electric Utilities

Case Study: Venezuelan Electric Utilities

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I. INTRODUCTION

The Basel Committee on Banking Supervision of the Bank for International Settlements (BCBS-BIS) [1], presents the most widely accepted definition of operational risks (OpR): *"The risk of direct or indirect loss resulting from inadequate or failed internal processes, people and systems or from external events"*.

In the XXI century there have been several financial crises caused by OpR in electric utilities, among which we can mention:

- In 2001, Enron, an electric utility in the US, went bankrupt and its auditor Arthur Andersen disappeared due to various internal and external massive frauds [2].
- In 2011 TEPCO (Tokyo Electric Power Company), an energy company that owns the Fukushima nuclear plant, was affected by external events: An earthquake measuring 9.0 on the Richter scale and the subsequent tsunami [3].

Therefore, these events show that the OpR are not unique to the banking sector, but can also be extrapolated to strategic organizations in countries or regions [4], because this could help prevent or mitigate the effects of the financial crisis.

Other researchers of OpR in electric utilities, like [5], have stated that most sources of renewable energy technologies are intermittent and volatile in nature and this creates many problems in the operational aspect. Also, an outdated operation paradigm of the grid has hindered the full potential of renewable energy projects and caused operational problems. Moreover, Klessmann et al. [6] suggest that the risks that can be most easily reduced by energy policy makers are the policy and regulatory risks.

The aim of this study is to adapt the guidelines issued by the BCBS-BIS concerning the administration of OpR, to "non-financial" companies by reviewing the state of the art. The methodology used in this study uses secondary data sources (reports from government agencies, literature reviews, newspaper, academic journals) in the analysis of the variables.

In order to achieve this objective a country is chosen within a specific geographic region and a strategic company whose scope substantially affects international markets is selected. The aim is to analyze whether there are grounds to subsequently apply the BCBS-BIS guidelines in a context different from the financial sector.

From this perspective an analysis of the OpR electricity companies in Venezuela is shown in this research, as it is estimated that the OpR may be an important factor of political, economic and social welfare of this nation, because as [7] indicates the State left its former status as regulatory and oversight body of the market to become part of the latter.

Among other macroeconomic factors affecting the Venezuelan energy market, the following should be mentioned: i. The monetary system is characterized as being very variable, stratified and volatile. ii. The (official) inflation, according to the Central Bank of Venezuela (BCV) until December 2014 has increased to 53.4% year on year, ranking as the highest in the world. iii. The GDP annual rate of growth in December 2013 was 1.3%, the lowest in Latin America and, iv. Unemployment, according to the National Statistics Institute (NSI), stood at 9.4% in January 2013 and is the highest south of the Rio Grande [8] [9].

II ADAPTATION OF DEL BCBS-BIS DIRECTIVES TO ELECTRIC UTILITIES

The BCBS-BIS [1], Chernobai et al. [10] and Jorion [11] define and divide the various sources of OpR for the financial

system. Considering the above and from meetings with experts from the electricity sector, the authors adapted the sources of OpR (see Figure 1) for electric utilities and their integration into existing risks (market, credit and liquidity) [12].

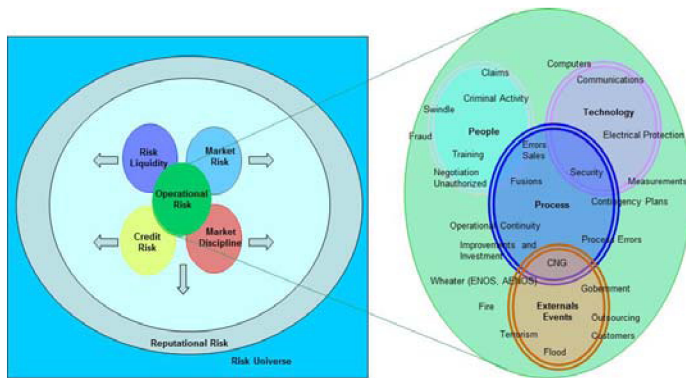


Figure 1: Risk Universe and primary sources of OpR
Source: Peña et al. [13]

III DEFINITION AND SELECTION OF THE RESEARCH UNIT

The main risk rating agencies such as Standard and Poor's [14], Moody's [15] and Fitch [16] classify in their reports Greece, Portugal, Spain, Argentina and Venezuela, among others, as the nations with highest country risk worldwide.

Additionally, these reports show how Venezuela went from being one of the most attractive countries in the world to invest in 1976 when it was classified 'Aaa' by these rating agencies to be one of the riskiest countries in the world, with its ranking falling in 2015 to CCC [14] [16], or Caa3 [15].

From the above data it was decided that the research unit should be Venezuela, due to the fact that this country has a "major impact" on world energy markets. Other countries with a slightly higher risk were discarded, because it is considered that the financial risks of these nations are more related to credit, liquidity or to financial markets, and are not of operational nature.

Since 2009, Venezuela suffers a deep energy crisis, which generates social unrest, as well as political and economic instability, which is the reason why the Venezuelan Electricity Sector (VES) has been chosen as the research unit of this study.

The VES is composed of a holding company called National Electricity Corporation Inc. (Corpoelec Inc.), which is divided into thirteen subsidiaries.

Corpoelec Inc. - C.A. Electrificación del Caroní (Corpoelec Inc.-EDELCA) is the main subsidiary of the area, because it produces 68 % of the electricity, which is one of the reasons why the company has been selected applying the Pareto principle [17] among other companies, in order to implement the study of OpR [18].

IV IDENTIFICATION AND DEFINITION OF THE SOURCES OF OpR IN THE RESEARCH UNIT AS A FUNCTION OF THE HISTORICAL DATA

In recent years, the VES suffers from voltage fluctuations, power failures, power and load losses and various other problems that keep the country and the electric utilities under emergency conditions. In view of this situation, the Ministry of Popular Power for Electric Power (MPPEP) established guidelines to mitigate such a serious scenario [19]. However, as it is shown below, these guidelines do not necessarily identify properly the OpR.

From the review of the state-of-the-art performed in this study it was found that among others, the following sources of OpR were present in the company under analysis:

A. Excessive dimension of Corpoelec Inc. and elimination of the free market for energy.

The suppression of the free market for energy is classified as a market risk. However, in this case this factor causes an oversized Corpoelec Inc., which considerably increases bureaucracy within this organization, being this one of the reasons why in this study these factors will be considered OpR.

This is supported by the fact that the government of Venezuela imposed by decree a reorganization of the electricity sector in 2007, consolidating the thirteen public and private companies that existed at that date in a single public holding company called Corpoelec Inc. The merger created an electric utility with a socialist philosophy, solely responsible for the generation, transmission, distribution and marketing of electricity in Venezuela, thus eliminating, any type of energy free market competition [20].

B. Decrease in the height of the reservoirs.

In the Caroni River basin is the largest hydropower complex in Venezuela and one of the largest in the world. This river is irregular in its flow, which directly affects the production of hydropower plants since they depend on the amount of water they can use. Therefore, the irregular flow of the river is one of the main sources of external OpR in the VES.

The irregularity of the flow of the Caroni River is seasonal and periodic. Therefore, it is reasonably predictable.

The lower Caroni hydroelectric complex consists of the Guri, Caruachi, Macagua I, II, III power plants and the Tocoma dam still under construction. The Guri hydroelectric plant is the most important of this complex, producing over 60% of the energy of Corpoelec Inc.-EDELCA.

The variation in the level of the Guri Dam is proportional to the flow of the river Caroni and therefore presents the same seasonality and frequency in its water level. It is noteworthy that the report [21] mentions the critical level for which it is not possible to continue producing electricity and places it at 240 meters above sea level [18] [24].

According to the Foundation for the Development of Electric Service of Venezuela (FUNDELEC), the flow is

affected to a greater extent when climatic phenomena such as ENOS (El Niño) and AENOS (La Niña) occur which increase the effect of seasonality, but are not the cause of it [22] [23].

River flow variability and variation in the height of reservoirs are enhanced by other external sources of OpR and processes, which are not the result of seasonality and frequency of rainfall, among which the following can be mentioned:

- Forest fires (either intentional or natural).

Corpoelec Inc.-EDELCA [18] gives an overview of how 921 fires were detected in the first half of 2008, but has informed that only 116 fires were fought without giving explanation of what occurs with the rest. In reviewing the reports of the remaining years of the first decade of the century it was observed that only in 2007 more than 19,000 hectares of forestland were affected.

- Indiscriminate logging

Reports of Corpoelec Inc.-EDELCA [24] mention the effects of indiscriminate logging on tributaries of the Caroni river, but the assessment of hectares affected is not displayed.

- Gates Systems

From interviews with Corpoelec Inc.-EDELCA staff, it was found that some gates systems, for both forced water pipes and spillways are very old. When closing the gates, large quantities of water are not turbinated and should be counted as potential losses of energy.

C. Deficiencies in the investment plans of hydropower plants.

Another source of OpR such as delays in investments in hydropower plants usually originate in external events or processes [12]. It is noted that until 1997, hydropower plants of the lower Caroni, went into operation at full load with a deviation between planned and executed of less than two years. Since then Caruachi was delayed six years and Tocoma reached its full capacity with a delay of 11 years.

Additionally, four plants were planned in the Upper Caroni: Tayucay, Aripichí, Eutobarima and Auraima (Rio La Paragua), which should have been completed before 2011 [24] [25], but so far construction has not started and according to official sources and the report of the Interamerican Development Bank (IDB) they are not expected to be built for environmental reasons [26] [27].

D. Non-technical losses in the distribution grid.

This OpR (event) is the result of external fraud to the utilities. It not only has an impact on the financial and economic data of the companies, but it also produces a considerable increase in the distribution system failures and quite often in the transmission systems.

The World Bank (WB) [28] shows how the Venezuelan national grid presents very high values of electrical losses. These are of two types: technical and non-technical.

Kirschstein and Rojas [29] in their research reports estimate that the Venezuelan National Interconnected System (VNIS) consolidated losses of 50% of the energy generated, where 40% corresponds to non-technical losses. Figure 2 shows a summary of this result in GWh of energy lost.

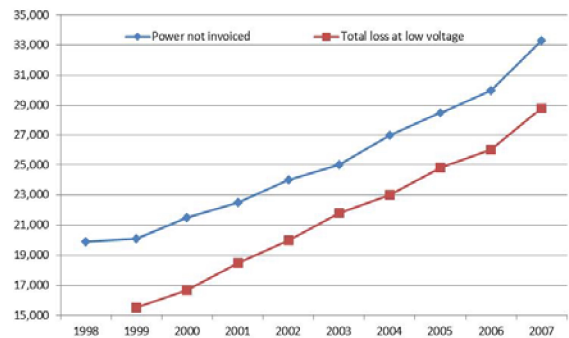


Figure 2. SIN electric energy losses, 1998–2007 period. Kirschstein and Rojas [29]

Therefore it can be inferred that the technical electrical losses in the VNIS are caused by obsolete equipment and power lines and deficiencies in maintenance, among other sources. However, it is widely known that most of the losses in the system are non-technical losses as shown in Figure 2.

To the above causes it can be added that most of the unbilled energy (non-technical losses) is due to the following reasons:

- Users with manipulated power meters with the intention of paying less for the energy consumed.
- There are many users without any power meters (self-connected).
- Street lighting consumption is not counted, so no payment is made for this concept.
- A large number of itinerant businesses illegally connect themselves to the electricity networks without the approval of the supplying firms.

E. Poor or nonexistent legal framework.

It is considered that the poor or nonexistent legal framework is a potential source of OpR from external fraud and processes, which interacts directly with legal risks [30].

In this sense, the legal uncertainty of the system or the low probability of enforcement leave power companies in an unfavorable environment that increases the sources of risks, because it precludes the payment of arrears of many of its subscribers, the elimination of fraud against the system, the prevention of embezzlement of public funds or of corruption inside and outside the companies, and makes it difficult to prevent failures in contracts [24] [31].

F. The Tarff Schedule.

The tariff schedule published by the NABRV [31], is the legal document based on which the electricity companies in Venezuela charge for the use of electricity services by consumers, according to various segmentations of customers.

It is considered that the tariff schedule is a source of liquidity risks. However, it becomes an OpR from external events and processes.

The annual average electricity price in Venezuela has been declining over the years. Currently, the electricity in Venezuela is sold at the lowest price worldwide [32] [33].

The evidence that it is an external source of OpR is that the Venezuelan tariff schedule has not been updated since 2003, as the increase in fees for the use of electricity in Venezuela is known among others, as a source of political and social instability as it happened in 1989 with the social uprising called "The Caracazo" [34]. It is therefore an inconsistency to introduce a rate increase before implementing the necessary maintenance and investment in the system [35].

G. High costs of Hydroelectric Power Plant Construction.

These OpR originate from internal and external fraud within Corpoelec Inc. and EDELCA, because when a hydroelectric plant is planned, the costs of human resources, construction, technology, expropriations, etc. are estimated in an initial project.

This initial project must not exceed a deviation of 10% until the end of the project, according to the European Regional Development Fund (ERDF) [36]. Hall et al. [37], rise these deviations to a maximum of 25%.

The final costs of some hydroelectric plants in several countries are shown in Table 1. From this table and the comparison with the initial cost it is detected that the deviation of the Caruachi Dam is 17% according to the report issued by the IDB [38]. However, in the case of the Tocomá Dam the deviation of investment would reach up to 422% according to the reports and statements issued by Corpoelec Inc.-EDELCA [39] and the IDB [40].

TABLE 1. Cost of installed Megawatts (in thousands of US-\$ per MW) in hydroelectric power plant worldwide

Dam	Civil work cost [MM\$]	Capacity [MW]	Cost per k\$/MW	End year of constr.	Country Location
Guri	6000	10000	600	1985	Venezuela
Tocoma	12000	2100	571.4	2015	Venezuela
Aysen	3200	2750	1164	-	Chile
Three Gorges	50000	22500	2222	2011	China
Itaipu	20000	14000	1429	2003	Brazil
Caruachi	2500	2160	1157	2006	Venezuela
Macagua II	1950	2540	768	1997	Venezuela
Boca del Cerro	5000	4200	1190	-	Mexico
Eastmain Rupert	1200	2500	480	2011	Canada
CBK Project	450	726.6	619	2000	Philippines
Ilisu	1520	1200	1267	2008	Turkey
Morowe	1250	1730	723	2009	Sudan
World Average	2500	2000	1250	2003	

Source: Adapted from Hall et al. [37], Lako et al. [41], Edenhofer et al. [42] and Corpoelec Inc.-EDELCA [18, 21].

H. Environmental damage caused by the construction of hydropower plants.

This is an external OpR generated by the intrinsic need for hydropower plants to cover large areas. These floodplains of dams cause environmental changes and damage the ecosystem.

In this context, Edenhofer et al. [42] show that in general it is estimated that hydropower is an environmentally friendly renewable energy source. However, the author explains how in most cases gases such as methane (CH₄), carbon dioxide (CO₂) and/or nitrous oxide (N₂O), which are part of the greenhouse effect, are generated.

Several global experiences refer to the environmental damages attributable to the construction of hydropower plants. Among other the Three Gorges Dam in China [43] where multiple ecological, cultural and social damages caused by the flooding of the area around the river Yang Tze is noteworthy.

In Corpoelec Inc.-EDELCA [18] [21] [24] [27] the presence of this risk becomes latent since it is planned to incorporate more than 9100 MW from four plants in the Upper Caroni: Tayucay, Aripichí, Eutobarima and Auraima, which were scheduled to be completed before 2011 [44].

There is a contradiction regarding the feasibility of these projects in the Upper Caroni. According to official sources these dams will not be built for environmental reasons. However, other sources like Bautista [45], present a forecast which shows that these dams are still part of hydropower projects to be developed by Corpoelec Inc.

I. Change of mission and vision of the organization

Corpoelec Inc. evolved from being a producer and marketer of electricity to include in its activities social projects ordered by the executive power. These projects consume many economic resources and do not contribute to financial profits [18]. This represents a change in the mission and vision of VES, which produces OpR originating from processes.

In Corpoelec Inc.-EDELCA the significant increase in the use of internal economic resources for EDELCA's social projects has been disclosed [18] [21] [27]. Simultaneously accounts receivable increased in the period 2004-2007. However, investments in social issues and accounts receivable generated do not represent sources of OpR, but are one part of the factors that cause them, as the decreased liquidity directly affects the capacity to undertake investment plans and improvement of various areas of the company, a situation that has been estimated to take place by the change in the mission and vision of the sector on a process or systemic risk.

J. Administrative Irregularities

This is a source of operational risk arising from internal fraud within the organization. This risk is associated within the company to staff managing budgets, bidding and direct contracting. The susceptibility of the organization to this source of OpR has been found in recent years, because there have been several complaints from sectors of society regarding the management of investments, maintenance, construction, etc.

K. Continuous changes of ministries, senior management of the electricity sector and external training.

It is estimated that in this case the OpR derive from the processes and people sources. Until 2002, the electricity companies were all ascribed to the Ministry of Energy and Mines (MEM), later became part of the Ministry of Energy

and Oil (MEO) and from 2009 to the MPPEP, which was created in response to the crisis of the electricity system. Additionally the Office of Interconnected Systems Operation was renamed National Management Center and FUNDELEC also became part of MPPEP [46].

Moreover, it was detected that most of the senior management staff of partner agencies in VES in the past 14 years had no training in the electricity sector. In most cases this management staff comes from military, political or family circles of the president of the republic and its subordinate sectors. Additionally, it was observed that there is a high staff turnover [47].

V CONCLUSIONS

This study was implemented through an analysis of historical variables, from sources of the VES official bodies, literature reviews, newspapers, journals and other sources, in order to analyze where operational risks with the greatest impact are present and/or have an incidence on the VES. The VES is comprised of 13 companies that make up the state holding company called Corpoelec Inc.

EDELCA, is the largest subsidiary of Corpoelec Inc., given that it produces more than 60% of the electricity consumed in Venezuela. Additionally, it owns the largest transmission network in the country. It is estimated that the main source of OpR in the VES is EDELCA. Therefore it is the Corpoelec Inc. subsidiary where strategies should be applied in order to reduce their effect.

The VES historical data show that the OpR are present in many of the production processes of its subsidiaries. In many cases it is difficult to determine when a financial risk pertains only to a subsidiary or when it is part of the entire organizational structure of the sector. Being the VES structured as a single holding the competences of each of the companies and institutions that compose it are not effectively defined.

By analyzing historical data of the Caroni river flow, the height of reservoirs and EDELCA staff surveys it is concluded that the reservoirs' level is not a true source of OpR, as it is considered that this problem is seasonal and cyclical and can be mitigated by performing the necessary investments.

The delay in diversifying sources of electricity generation, the delay in the implementation of new hydroelectric plants and shortcomings in the maintenance of existing installations for generation, transmission and distribution of electricity are associated with deficiencies in investment plans, which are of high socio-economic impact for the entire production system of the country.

Non-technical losses in the EDELCA and VES power distribution networks are mainly due to the critical state in which they are, which is a continuous and diverse source of OpR and operational events. Strategies should focus on mitigating the effects of the OpR in electricity distribution networks of the INS.

The poor or non-existent legal framework is reflected in the fact that between transmission and distribution lines

electrical system losses amount to about 50%. A high percentage of the energy produced is not billed, which is not an OpR, but an event of high impact and frequency. To continue investing in power generation without correcting fraud will not serve to reduce the OpR, but will instead help increase the electricity losses.

The lack of adaptability of the tariff schedule is associated with illiquidity and therefore does not involve an OpR (liquidity risk). However, since cash flow is not generated as a product of its own revenues, there is a need to access external funding, either through international loans, oil revenues, etc. This situation produces new OpR in all levels of EDELCA and VES, with a high impact on social and economic aspects.

The construction of hydropower plants presents a number of OpR associated with managing budgets because these are susceptible to fraud. Additionally, dams occupy large tracts of land, and pose an environmental impact that is necessary to assess prior to the execution of the construction work.

The social approach that has been required from EDELCA has generated distractions in human resources that have diverted their attention from the basic processes: Producing electricity with high levels of reliability and quality. Therefore, it is suggested to totally depoliticize the company and that political affinities do not become parameters for measuring the qualities and skills of the staff who work there, because its function is to provide a technical product to the nation.

The administrative irregularities are caused by internal fraud within the organization and are associated with human resources managing budgets, bidding and direct contracting.

The frequent ministerial and organizational changes undermine the proper management of the company and of the VES. The change of middle managers whenever senior management is changed makes it impossible to plan realistically for the medium and long term.

Since the training of senior management is different from the VES staff they are not familiar with the production processes and the various facets of the business, which generates a systemic risk.

Authors of this paper showed in [48] many sources of risks and through this article they are complementing all roots of OpR. In their papers [49] [50] they are contributing to the development of their future model of the operational risk management to show to stakeholders the real situation of the VES and to the electric utilities around the world that it is possible to adapt to the recommendations from BCBS-BIS.

On the other hand, when the authors compared OpR sources between this paper with articles of other OpR researchers in electric utilities they concluded that the studies are complementary and in any case are not mutually exclusive. Finally, we can say that the multiple OpR roots defined by international financial organizations, among which the BCBS-BIS, are enriched.

This study attempts to establish with sufficient grounds the existence of OpR within the VES and its most important

company Corpoelec Inc.-EDELCA, and the empirical application of the BCBS-BIS guidelines to the selected electricity sector confirms that it is possible to implement and adapt these guidelines to other industries different from the financial sector.